Fragmentation Analysis Utility

and

Fragmentation Cost Analysis

User's Guide

September 1994

This document describes the installation and operation of Executive Software International's Fragmentation Analysis Utility (also known as the Disk Analysis Utility) and Fragmentation Cost Analysis.

This document is intended for OpenVMS system managers.

Revision/Update Information: This is a new manual.

Operating System: OpenVMS VAX and OpenVMS AXP

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Manual Objectives

After reading and understanding this document, the reader should be able to successfully install and operate the Fragmentation Analysis Utility and the Fragmentation Cost Analysis.

Intended Audience

This manual is intended for OpenVMS™ VAX™ and AXP™ system managers.

Structure of This Document

- Chapter 1 describes how to install the Fragmentation Analysis Utility and the Fragmentation Cost Analysis.
- Chapter 2 describes how to run the Fragmentation Analysis Utility.
- Chapter 3 describes how to run the Fragmentation Cost Analysis.

Conventions

The following conventions are used throughout this document:

`Disk:`

In examples, typewriter-style print that is not bold indicates messages and prompts displayed on your screen.

`FAU_MENU`

In examples, bold typewriter-style print illustrates characters you type.

`disk_name`

In examples, italic typewriter-style print shows when you should enter or type an appropriate value, but not the exact characters shown.

`$ FAU_MENU FAU disk_name /qualifier`

In examples, mixed print styles show separation between prompts, specific characters you type, and values you are expected to substitute.

Return

This describes the carriage return key on the terminal keyboard.

Ctrl-W

This describes the combination of holding down the key labeled Ctrl while you press the key labeled W. All Ctrl key combinations are shown in this manner.

Introduction

File fragmentation—how bad is it on your VAX or AXP? File fragmentation is inherent to OpenVMS—the condition in which files are scattered in pieces (fragments) all over the disk, causing needless disk I/Os. It is a condition which, if unhandled, can slow a system down dramatically.

Using the OpenVMS MONITOR utility, you can gather some clues about file fragmentation. You can find indicators of things that may or may not be caused by fragmentation.

The Fragmentation Analysis Utility, however, deals directly with fragmentation; the average state of fragmentation on your disks, the sizes and fragmentation of your free spaces, the number of fragmented files and how fragmented they are, and much more. It can provide a quick summary, or a detailed analysis. It can be run at any time on any Digital-supported disk on an OpenVMS system. It is not necessary to allocate the disk, dismount it, or stop users from accessing it.

NEW - Fragmentation Cost Analysis feature

Performance loss from fragmentation is costing your company money. Your company is paying for the extra time computer users are waiting for fragmented files. User salaries vary, but a portion of these salaries is being thrown away simply waiting for the computer. Additionally, the cost of the time to perform backup and restore periodically must also be figured in.

The new Fragmentation Cost Analysis will quickly and easily provide an estimate of how much fragmentation is costing you.

1 INSTALLATION

1.1 OpenVMS Platforms and Versions Supported

A single user's guide is provided for the Fragmentation Analysis Utility and the Fragmentation Cost Analysis running on both the VAX and the Alpha AXP™ platforms. This is in alignment with the documentation strategy currently used by Digital Equipment Corporation in their own product documentation.

These utilities function the same on both platforms. The differences in OpenVMS between the two platforms are minor. Any differences will be clearly noted in this documentation.

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis for OpenVMS VAX are supported on versions 5.0 through 6.1 of the OpenVMS VAX operating system. They are not supported for versions prior to VMS 5.0.

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis for OpenVMS AXP are supported on versions 1.0 through 6.1 of the OpenVMS AXP operating system.

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis are supported on all VAX CPUs from Digital that run the OpenVMS VAX operating system.

These utilities are fully supported on the VAXstation™ 3100, but not on the RISC-based DECstation™ 3100.

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis are supported on all Alpha AXP CPUs from Digital that run the OpenVMS AXP operating system.

These utilities are installed using the VMSINSTAL command procedure used to install your OpenVMS operating system and layered products. While VMSINSTAL can be used from any privileged account, Executive Software recommends that you log into the system manager account (**SYSTEM**, UIC [1,4]).

Use VMSINSTAL in accordance with Digital's *VMS Installation and Operations* guides.

1.2 VAX Resource Requirements

The VAX version of the Fragmentation Analysis Utility and Fragmentation Cost Analysis can be installed in any directory on any disk device on your system. During installation of these utilities, approximately 2000 free disk blocks are required for temporary files and directories on SYS$SYSDEVICE. After the installation, the Fragmentation Analysis Utility and Fragmentation Cost Analysis files take less than 450 blocks of disk space.

Use the DCL command SHOW DEVICES /FULL to make sure you have sufficient space on SYS$SYSDEVICE for the installation before beginning.

1.3 AXP Resource Requirements

The Alpha AXP version of the Fragmentation Analysis Utility and Fragmentation Cost Analysis can be installed in any directory on any disk device on your system. During installation of these utilities, approximately 2000 free disk blocks are required for temporary files and directories on SYS$SYSDEVICE. After the installation, the Fragmentation Analysis Utility and Fragmentation Cost Analysis files take less than 750 blocks of disk space.

Use the DCL command SHOW DEVICES /FULL to make sure you have sufficient space on SYS$SYSDEVICE for the installation before beginning.

1.4 Privileges Required

The procedures and the executable image that make up the Fragmentation Analysis Utility and the Fragmentation Cost Analysis require the privileges shown in Table 1–1:

Table 1–1 Required Privileges

Image or Procedure Name	Privileges
FRAG_ANALYSIS_*xxx*.EXE[1]	CMKRNL, LOG_IO, (READALL or SYSPRV)
FCA.COM	TMPMBX, NETMBX

[1]The *xxx* portion of the image name is either *AXP* or *VAX*, depending upon your computer platform.

1.5 Terminal Display Requirements

The displays of the Fragmentation Analysis Utility and Fragmentation Cost Analysis are compatible with VT100 and later terminals and with terminal emulation windows under DECwindows, DECwindows Motif, or VWS. VT52s and LA-series hardcopy terminals may be used for software installation, but are not supported for the menus.

1.6 Disks Supported

The Fragmentation Analysis Utility and Fragmentation Cost Analysis support the entire range of OpenVMS ODS-2 disk types: System disks, common system disks, quorum disks, user disks, volume sets, stripesets, and shadow sets. These utilities work in clusters whether the disk is on a local controller, an HSC, MSCP served, or LAVC-style MSCP served.

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis are designed for any Digital-supported configuration.

1.7 Installation Overview

The entire procedure for getting the Fragmentation Analysis Utility and Fragmentation Cost Analysis up and running on your system consists of the following:

- Do a full BACKUP of the system disk. This is a standard precaution recommended by Digital whenever using VMSINSTAL.
- Install the Fragmentation Analysis Utility and Fragmentation Cost Analysis using VMSINSTAL. See Section 1.8
- Define a symbol to invoke the Fragmentation Analysis Mini-Menu. See Section 1.10.

1.8 Installation Procedure

The Fragmentation Analysis Utility and the Fragmentation Cost Analysis are distributed together on the same media. Both utilities are intended to be installed in the same directory. During the installation procedure, you are allowed to specify the device and directory locations for the two utilities. By default, they are installed at SYS$SYSDEVICE:[ESI_FAU]

Step 1:

Log into the OpenVMS system manager's account (username **SYSTEM**, UIC [1,4]) and give your process the OPER and SETPRV privileges. This ensures that you will have access to the files and images needed for the installation and that files created during the installation will be created properly.

The device name *DUA0* is used as an example in this dialog. During installation, the physical name of SYS$SYSDEVICE for your system will appear in place of *DUA0* shown in the dialog below.

Step 2:

Set the default disk directory to SYS$UPDATE:

```
$ SET DEFAULT SYS$UPDATE
```

Step 3:

Execute the VMSINSTAL command procedure defining the product being installed, followed by the input device name (CD ROM drive *DKB500:* in this example). Note that the directory specification shown in the example below only applies to installation from the CD ROM distribution medium. Omit the directory specification if you are installing from magnetic tape media.

```
$ @VMSINSTAL FAU DKB500:[ESI.UTILITIES.FRAG_ANALYSIS.V11.KIT]
```

VMSINSTAL will begin by displaying some information about the state of your system, such as whether DECnet™ is running, then ask whether you want to continue. Respond with YES only if the information displayed is as expected.

Note: It is not necessary to shut down DECnet or log off users to install the Fragmentation Analysis Utility.

```
* Do you want to continue anyway [NO]? YES
```

Step 4:

Next, VMSINSTAL will ask whether you are satisfied with the backup of your system disk. While every precaution has been taken to prevent adverse side-effects during installation of our product, Digital and Executive Software recommend having a current full backup of your system disk when installing any new software.

```
* Are you satisfied with the backup of your system disk [YES]? YES
```

Step 5:

If you are installing from magnetic tape, physically mount the distribution tape on the specified drive when requested to do so by VMSINSTAL. Then answer the *ready* question.

```
* Are you ready? YES
```

There will be a period of a few minutes of processing. Read all messages and answer any questions asked. Normally, the installation proceeds like this:

```
%MOUNT-I-MOUNTED,FAU mounted on DKB500:
The following products will be processed:

  FAU V1.1

       Beginning installation of FAU V1.1 at 14:36

%VMSINSTAL-I-RESTORE, Restoring product save set A...
* Do you want to purge files replaced by this installation [YES]? YES
```

Step 6:

A temporary directory is created; product saveset *A* is restored; and the copyright notice is displayed.

Press Return when prompted to do so.

Step 7:

Next, you are given the opportunity to specify the device and directory where the Fragmentation Analysis Utility and the Fragmentation Cost Analysis will be installed. Press Return to accept the default, or answer NO at the following prompt:

```
* OK to install FAU at SYS$SYSDEVICE:[ESI_FAU] [YES]? YES
```

If you answer NO, you will be prompted to enter the device and directory where you want the Fragmentation Analysis Utility and Fragmentation Cost Analysis files to reside.

Step 8:

There will be another period of a few minutes of processing. Watch for errors or any other messages, such as:

```
FAU will be installed at SYS$SYSDEVICE:[ESI_FAU]

%VMSINSTAL-I-SYSDIR, This product creates system disk directory DUA0:[ESI_FAU].

Copying files, please wait...

All files copied and secured
%VMSINSTAL-I-MOVEFILES, Files will now be moved to their target directories...

        Installation of FAU completed at 14:37

 VMSINSTAL procedure done at 14:37
```

Step 9:

Since VMSINSTAL modifies your process environment, you should log out and back on to your system after this installation is complete.

1.9 Fragmentation Analysis Utility Kit Files

After installation, the Fragmentation Analysis Utility and Fragmentation Cost Analysis files reside in **SYS$SYSDEVICE:[ESI_FAU]** if the default directory was accepted at installation time. This directory specification will differ if you specified an alternate directory location for the Fragmentation Analysis Utility and Fragmentation Cost Analysis files. The files installed are shown in Table 1–2.

Table 1–2 Files Distributed

Kit Files
FAU_MINI_MENU.COM
FCA.COM
FRAG_ANALYSIS_*xxx*.EXE[2]
Total of 3 Files.

[2]The *xxx* portion of the filename will be either *AXP* or *VAX*, depending upon your computer platform.

1.10 Defining a Symbol for the Fragmentation Analysis Mini-Menu

The Fragmentation Analysis Utility includes a command procedure which makes it easy to invoke the Fragmentation Analysis Utility and the Fragmentation Cost Analysis. This command procedure displays a small menu of abbreviated commands. Invoke the Fragmentation Analysis Mini-Menu command in this manner:

```
$ @device_name:[directory]FAU_MINI_MENU.COM
```

where *device_name*:[*directory*] is the device and directory where the Fragmentation Analysis Utility and Fragmentation Cost Analysis files were installed during the installation procedure.

For ease of use, define the following symbol in the system-wide login procedure or the individual login procedures of the users needing access to the Fragmentation Cost Analysis and the Fragmentation Analysis Utility:

```
$ FRAG_MENU == "@device_name:[directory]FAU_MINI_MENU.COM"
```

Once this has been done, enter **FRAG_MENU** at the DCL prompt to access the Fragmentation Analysis Mini-Menu.

2 FRAGMENTATION ANALYSIS UTILITY OPERATION

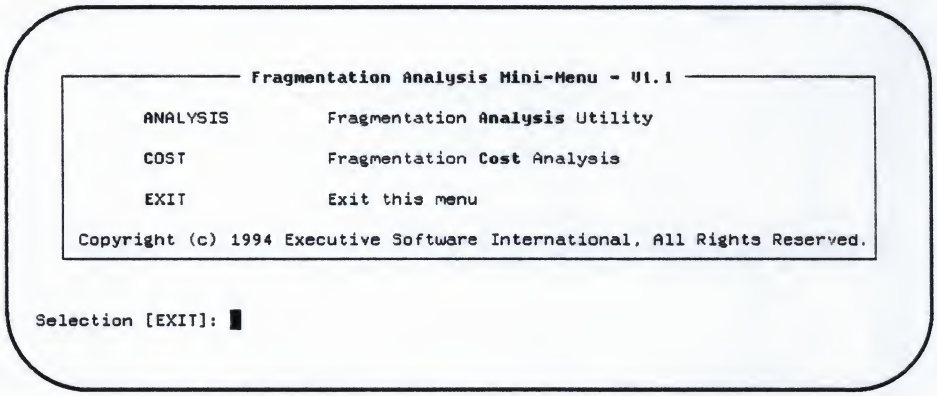
The Fragmentation Analysis Utility (also known as the Disk Analysis Utility) is useful for determining the degree of fragmentation of the files and free space on a disk. It can provide anything from a quick summary to a very detailed analysis.

2.1 Running the Fragmentation Analysis Utility

The Fragmentation Analysis Utility can be run at any time on any Digital-supported disk. It is not necessary to allocate the disk, dismount it, or stop users from accessing it.

The Fragmentation Analysis Utility is invoked from the Fragmentation Analysis Mini-Menu shown in Figure 2–1:

Figure 2–1 Fragmentation Analysis Mini-Menu



From the DCL prompt, enter **FRAG_MENU** to invoke the Fragmentation Analysis Mini-Menu. The Fragmentation Analysis Utility can then be invoked with the command:

```
Selection [EXIT]: ANALYSIS disk_name /qualifiers
```

where *disk_name* is the device name of the disk to be analyzed. If *disk_name* is omitted, the Fragmentation Analysis Utility will prompt for the disk name. Only one disk can be specified at a time. The optional */qualifiers* represent Fragmentation Analysis Utility qualifiers, as shown in Table 2–1 and described in Section 2.2.2.

The Fragmentation Analysis Utility can also be invoked from a command procedure, either interactively or from a batch job. To use the Fragmentation Analysis Utility in this way, create a command procedure similar to the following:

```
$! ANALYZE_DISK_DUA0.COM -- Analyze Disk DUA0
$
$  RUN device_name:[directory]:FRAG_ANALYSIS_xxx
      DUA0: /FULL
$  exit
```

The device name *DUA0* used in the above example can be replaced with any valid disk device name. Also note that the *xxx* portion of the image name is either *AXP* or *VAX*, depending upon your computer platform.

2.2 Qualifiers

Table 2–1 Fragmentation Analysis Utility Qualifiers

Qualifier	Default	Description
/BRIEF	YES	Only Free Space Summary and File Info
/DIRECTORY_FILES	NO	List Directory Files
/DISPLAY_MAP_PTRS	NO	Display map pointers for each named file
/FILE_SUMMARY	NO	List File Sizes Summary
/FRAG_SUMMARY	NO	List File Fragments Summary
/FREE_DETAIL	NO	List Free Space Detail
/FREE_SUMMARY	YES	List Free Space Summary
/FULL	NO	Full Listing
/LARGEST_FREE	NO	List 16 Largest Free Spaces
/LOCATE=(start,end)	NO	List files with allocation in block range
/MOST_FRAGMENTED_FILES[=n]	NO [64]	List the "n" Most Fragmented Files
/MULTIHEADER_FILES	NO	List Multi-Header Files
/MULTIVOLUME_FILES	NO	List Multi-Volume Files
/NAME_BY_FID=file_identification	NO	Return filename By File Identification Number
/OUTPUT=filespec	SYS$OUTPUT	Output information to this filespec
/PLACED_FILES	NO	List Placed Files
/RESERVED_FILES	NO	List Reserved Files
/ZERO_LENGTH	NO	List Zero Length Files

2.2.1 Qualifier Syntax

When the Fragmentation Analysis Utility is invoked using a foreign command, qualifiers are placed after the device name, on the same line as the command:

```
$ FRAG_MENU ANALYSIS DUA0: /FULL /NODIRECTORY_FILES
```

When the Fragmentation Analysis Utility is invoked using the DCL RUN command, qualifiers are placed after the device name, on the line following the command:

```
$ RUN device_name:[directory]FRAG_ANALYSIS_xxx
Disk: DUA0: /FULL /NODIRECTORY_FILES
```

It is not necessary to use a space to separate qualifiers from device names or from one another.

2.2.2 Fragmentation Analysis Utility Qualifier Descriptions

/BRIEF (default)
/NOBRIEF

This qualifier limits output to a brief summary of the condition of the files and free space on the disk. The output consists of the *Free Space Summary* and *File Information* sections, and conveniently fits on a 24-line terminal display.

/NOBRIEF causes all sections to be included in the output, just as if /FULL had been specified. The default is /BRIEF.

/DIRECTORY_FILES
/NODIRECTORY_FILES (default)

This qualifier causes directory files to be included in the list of *Special Case Files*. The default is /NODIRECTORY_FILES.

/DISPLAY_MAP_PTRS
/NODISPLAY_MAP_PTRS (default)

When this qualifier is selected, any file names displayed in *Special Case Files* or *Most Fragmented Files* are accompanied by information describing the location of the files on the disk. The default is /NODISPLAY_MAP_PTRS.

/FILE_SUMMARY
/NOFILE_SUMMARY (default)

This qualifier causes the *File Sizes Summary* to be included in the output. The default is /NOFILE_SUMMARY.

/FRAG_SUMMARY
/NOFRAG_SUMMARY (default)

This qualifier causes the *File Fragments Summary* to be included in the output. The default is /NOFRAG_SUMMARY.

/FREE_DETAIL
/NOFREE_DETAIL (default)

This qualifier causes the *Free Spaces Distribution* and the *Free Space Detail* to be included in the output. The default is /NOFREE_DETAIL.

/FREE_SUMMARY (default)
/NOFREE_SUMMARY

This qualifier causes the *Free Space Summary* to be included in the output. The default is /FREE_SUMMARY.

/FULL
/NOFULL (default)

This qualifier causes all sections to be included in the output. The default is /NOFULL.

/LARGEST_FREE
/NOLARGEST_FREE (default)

This qualifier generates a list of the 16 largest free spaces on the specified disk, giving the size in blocks and location by Logical Block Number (LBN) of each. The default is /NOLARGEST_FREE.

/LOCATE=(start,end)
/NOLOCATE (default)

This qualifier generates a list of the file specifications of all files with blocks allocated in the specified range of Logical Block Numbers (LBN's). The default is /NOLOCATE.

/MOST_FRAGMENTED_FILES
/MOST_FRAGMENTED_FILES=n
/NOMOST_FRAGMENTED_FILES (default)

This qualifier causes the list of *Most Fragmented Files* to be included in the output. The default is /NOMOST_FRAGMENTED_FILES. When /MOST_FRAGMENTED_FILES is used without a parameter, the parameter defaults to 64. Note that, since the Fragmentation Analysis Utility analyzes each file header separately, it is possible for the name of a multi-header file to appear more than once in this list, one time for each header.

/MULTIHEADER_FILES
/NOMULTIHEADER_FILES (default)

This qualifier causes multi-header files to be included in the *Special Case Files*. The default is /NOMULTIHEADER_FILES.

/MULTIVOLUME_FILES
/NOMULTIVOLUME_FILES (default)

This qualifier causes multi-volume files to be included in the *Special Case Files*. The default is /NOMULTIVOLUME_FILES.

/NAME_BY_FID=fid
/NONAME_BY_FID (default)

This qualifier defeats the fragmentation analysis altogether and returns the full file specification for the specified File Identification Number. When specifying the File Identification Number, enter only the first field of the three fields shown in the File Identification Number. For example, for a file identified as (10932,47,0), enter only the file number, which is 10932 in this example. The default is /NONAME_BY_FID.

/OUTPUT=filespec
/OUTPUT=SYS$OUTPUT (default)

This qualifier causes the output to be redirected to a file instead of to the terminal display. The default is /OUTPUT=SYS$OUTPUT.

/PLACED_FILES
/NOPLACED_FILES (default)

This qualifier causes placed files to be included in the *Special Case Files*. The default is /NOPLACED_FILES.

/RESERVED_FILES
/NORESERVED_FILES (default)

This qualifier causes reserved files to be included in the *Special Case Files*. The default is /NORESERVED_FILES.

/ZERO_LENGTH
/NOZERO_LENGTH (default)

This qualifier causes a list of zero-length files (files that have no blocks allocated to them) to be included in the *Special Case Files*. The default is /NOZERO_LENGTH.

2.3 Fragmentation Analysis Utility Output Example

Example 2–1 on the following page shows an example of the full Fragmentation Analysis Utility output after entering this command at the Fragmentation Analysis Mini-Menu prompt:

```
Selection [EXIT] ANALYSIS BOOT$DUA0 /FULL
```

Example 2–1 Fragmentation Analysis Utility Output

```
                        Fragmentation Analysis Utility
FRAGMENTATION_ANALYSIS
Copyright (c) 1994 Executive Software International. All Rights Reserved.
_BOOT$DUA0:                                  6-JUL-1994 17:36:49.64
Number of Usable Blocks:   204864       Cluster Size           :        3

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<  Free Space Summary  >>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Total Free Space Size  :    78260       Smallest Free Space    :      676
Number of Free Spaces  :       16       Largest  Free Space    :     9366
#Spaces = 82% of Total:        10       Mean Size of Free Space:     4891

<<<<<<<<<<<<<<<<<<<<<<<<<<<  16 Largest Free Spaces  >>>>>>>>>>>>>>>>>>>>>>>>>>>

Start LBN   Size    Start LBN   Size    Start LBN   Size    Start LBN   Size
--------- --------- --------- --------- --------- --------- --------- ---------
   204828      9366    196610      6760     68198      4852     73886      3166
    98304      8232    190860      5748     78336      4126     57390      1516
   118748      7576     51854      5524     36978      3982    165152      1036
   139196      6774     59472      5302     90274      3624     47986       676

<<<<<<<<<<<<<<<<<<<<<<<<<<<  Free Spaces Distribution  >>>>>>>>>>>>>>>>>>>>>>>>>>>

     Size Range          # Spaces          Size Range          # Spaces
--------------------     ---------     --------------------     ---------
       1 to        2   -         0          511 to     1022   -         1
       3 to        6   -         0         1023 to     2046   -         2
       7 to       14   -         0         2047 to     4094   -         3
      15 to       30   -         0         4095 to     8190   -         8
      31 to       62   -         0         8191 to    16382   -         2
      63 to      126   -         0        16383 to    32766   -         0
     127 to      254   -         0        32767 to    65534   -         0
     255 to      510   -         0        65535 to   311198   -         0

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<  Free Space Detail  >>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Start LBN   Size    Start LBN   Size    Start LBN   Size    Start LBN   Size
--------- --------- --------- --------- --------- --------- --------- ---------
    36978      3982     59472      5302     90274      3624    165152      1036
    47986       676     68198      4852     98304      8232    190860      5748
    51854      5524     73886      3166    118748      7576    196610      6760
    57390      1516     78336      4126    139196      6774    204828      9366

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<  Special Case Files  >>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Reserved File    : (1,1,0) [000000]INDEXF.SYS;1
Reserved File    : (2,2,0) [000000]BITMAP.SYS;1
Zero Length File : (3,3,0) [000000]BADBLK.SYS;1
Reserved File    : (3,3,0) [000000]BADBLK.SYS;1
Reserved File    : (4,4,0) [000000]000000.DIR;1
Zero Length File : (5,5,0) [000000]CORIMG.SYS;1
Reserved File    : (5,5,0) [000000]CORIMG.SYS;1
Zero Length File : (6,6,0) [000000]VOLSET.SYS;1
Reserved File    : (6,6,0) [000000]VOLSET.SYS;1
Zero Length File : (7,7,0) [000000]CONTIN.SYS;1
Reserved File    : (7,7,0) [000000]CONTIN.SYS;1
Zero Length File : (8,8,0) [000000]BACKUP.SYS;1
Reserved File    : (8,8,0) [000000]BACKUP.SYS;1
Zero Length File : (9,9,0) [000000]BADLOG.SYS;1
Reserved File    : (9,9,0) [000000]BADLOG.SYS;1
Zero Length File : (36,31,0) [SYS6.SYSMGR]ACCOUNTNG.DAT;1
Zero Length File : (581,15,0) [SYS6.SYSMGR]VMSIMAGES.DAT;14
Multi-Header File: (866,2,0) [SYSE.V4COMMON.SYSLIB]BASIC$STARLET.TLB;1
Placed File      : (1132,20,0) [SYSE.V4COMMON.SYSEXE]JBCSYSQUE.DAT;3
Multi-Header File: (1221,9,0) [SYSE.V4COMMON.SYSLIB]BASIC$STARLET.TLB;1
Zero Length File : (1478,1,0) [SYSE.V4COMMON.SYSEXE]NOTICE.TXT;2
```

Example 2–1 Cont'd on next page

Example 2–1 (Cont.) Fragmentation Analysis Utility Output

```
<<<<<<<<<<<<<<<<<<<<<<<<<<<<  Most Fragmented Files  >>>>>>>>>>>>>>>>>>>>>>>>>>>>

      73: (86,24,0) [SYS1.SYSERR]ERRLOG.SYS;1
      34: (116,7,0) [SYS3.SYSERR]ERRLOG.SYS;1
      19: (26,73,0) [SYS0.SYSERR]ERRLOG.SYS;1
      10: (81,68,0) [SYS2.SYSERR]ERRLOG.SYS;1
       9: (1132,20,0) [SYSE.V4COMMON.SYSEXE]JBCSYSQUE.DAT;3
       7: (1,1,0) [000000]INDEXF.SYS;1
       6: (24,1,0) [SYS0.SYSEXE]PAGEFILE.SYS;1
       4: (34,6,0) [SYS2.SYSEXE]PAGEFILE.SYS;1
       4: (1051,3,0) [SYS3.SYSEXE]PAGEFILE.SYS;1
       3: (1009,8,0) [SYS0.EASYLINK]INMAIL.LOG;1
       3: (1206,24,0) [SYS6.SYSEXE]PAGEFILE.SYS;1
       3: (1225,20,0) [SYS3.SYSMGR]OPERATOR.LOG;70
       2: (230,2,0) [SYS5.SYSEXE]PAGEFILE.SYS;1
       2: (316,11,0) [SYS0.EASYLINK]EMC.LOG;72
       2: (618,8,0) [SYS1.SYSMGR]OPERATOR.LOG;92
       2: (1112,15,0) [SYS2.SYSMGR]OPERATOR.LOG;68
       2: (1567,1,0) [SYSE.V4COMMON.SYSEXE]SYSUAF.DAT;3
       2: (1802,3,0) [SYSE.V4COMMON.SYSEXE]SYS.EXE;4

<<<<<<<<<<<<<<<<<<<<<<<<<<<<  File Information  >>>>>>>>>>>>>>>>>>>>>>>>>>>>

Maximum Number of Files:    51866       # Reserved     Files   :        9
Total Number of Files  :     1536       # Placed       Files   :        1
Total Size of all Files:   230607       # Multi-Hdr File Hdrs  :        2
Smallest File Size     :        1       # Multi-Volume Files    :        0
Largest  File Size     :    50000       # Directory    Files   :      125
Mean  Size of all Files:      150       # Zero Length Files    :        9
# Extent Headers       :        1       # Files with Frags >= 2:       18
Total File Fragments   :     1694       Lost Blks/Extent Cache :     2333
Mean Fragments per File:     1.11       Total Split I/Os       :     1291

<<<<<<<<<<<<<<<<<<<<<<<<<<<<  File Sizes Summary  >>>>>>>>>>>>>>>>>>>>>>>>>>>>

     Size Range           # Files          Size Range           # Files
--------------------     ---------     --------------------     ---------
       1 to       2   -       335           511 to     1022   -        11
       3 to       6   -       288          1023 to     2046   -         8
       7 to      14   -       179          2047 to     4094   -         4
      15 to      30   -       267          4095 to     8190   -         1
      31 to      62   -       187          8191 to    16382   -         4
      63 to     126   -       134         16383 to    32766   -         2
     127 to     254   -        81         32767 to    65534   -         1
     255 to     510   -        34         65535 to   311198   -         0

<<<<<<<<<<<<<<<<<<<<<<<<<<<<  File Fragments Summary  >>>>>>>>>>>>>>>>>>>>>>>>>>>>

  Fragments      # Files       Fragments      # Files       Fragments      # Files
 -----------    ---------     -----------    ---------     -----------    ---------
      0      -          9          6      -          1         12      -          0
      1      -       1510          7      -          1         13      -          0
      2      -          6          8      -          0         14      -          0
      3      -          3          9      -          1         15      -          0
      4      -          2         10      -          1         16      -          0
      5      -          0         11      -          0         17+     -          3
```

2.4 How to Read the Fragmentation Analysis Utility

2.4.1 Heading

The heading includes the title, the version of the program used, a copyright notice, the physical device name of the disk analyzed and a date/time stamp indicating when the report was generated. The physical device name of the disk is provided to ensure there is no mistake about which disk is being analyzed, because the utility accepts logical names as input.

Number of Usable Blocks is the total number of usable blocks on the disk, whether allocated or free. This is provided as general information about your disk.

Cluster size is the number of blocks in each cluster of blocks. Disk blocks are grouped into clusters, which are groups of blocks allocated as a unit. A cluster is the minimum allocation quantity for a disk. It is also the number of blocks represented by each bit in the storage bitmap.

Disks larger than 50,000 blocks default to a cluster size based on the disk size when initialized, usually three, but this may not be the best value for your intended use. A cluster size of one incurs the maximum possible overhead in disk I/O, but assures the availability of every last block on the disk. A cluster size of three reduces the size of the storage bitmap on the disk by a factor of three and speeds file allocation, but one or two disk blocks are wasted for every file that is not a multiple of three blocks. If your average file size is one, this could be a tremendous waste.

2.4.2 Free Space Summary

This section is part of the brief default display.

Total Free Space Size is the number of disk blocks that are unoccupied, including the number of blocks in the extent cache for this disk on the local node. This number is useful in determining how full your disk is.

Number of Free Spaces is the total number of spaces (of any size) on the disk. This is a good general indication of how fragmented the free space is on your disk.

#Spaces = nn% of Total indicates how many spaces are required to represent 80% or more of the free space on the disk. In Example 2–1, ten spaces constitute 82% of the free space on the disk. As a general rule of thumb, this figure should be as low as possible – 5 is a good goal.

Smallest Free Space is the size in blocks of the smallest space on the disk.

Largest Free Space is the size in blocks of the largest space on the disk.

Mean Size of Free Space is the average size of a space, calculated by dividing the total free space size in blocks by the number of free spaces. This is also a good indicator of the condition of the free space on your disk.

2.4.3 16 Largest Free Spaces

The table headed *16 Largest Free Spaces* shows the location and size of the 16 largest contiguous spaces on the disk.

2.4.4 Free Spaces Distribution

The table headed *Free Spaces Distribution* shows the number of spaces on the disk categorized by size in blocks. In Example 2–1, there is one space from 511 to 1022 blocks in size, two more in the range 1023 to 2046, three in the range 2047 to 4094, eight in the range 4095 to 8190 and two between 8191 and 16,382.

2.4.5 Free Space Detail

The table headed *Free Space Detail* shows the size and location of unallocated spaces on the disk, in order from LBN 0 to the end of the disk.

2.4.6 Special Case Files

The table headed *Special Case Files* shows files that may be of special interest to the Data Center Manager. The list includes files reserved for use by the file system, directory files, zero length files, multi-header files, placed files and any multi-volume files if the disk is part of a volume set.

2.4.7 Most Fragmented Files

The table headed *Most Fragmented Files* shows the files that have the most fragments, in order from most fragmented to least. Only files that have two or more fragments are listed, and the size of the list is limited by the qualifier **/MOST_FRAGMENTED_FILES=n** (64 files by default). The number of fragments in each file is shown as well. Multi-header files are listed once for each header.

2.4.8 File Information

Below the *Special Case Files* table is a collection of statistical information about the files and fragments on the disk. *Fragments* means *pieces of files*. This section is part of the brief default display.

Maximum Number of Files is the total number of files that can be created on the disk. This is given as general disk information.

Total Number of Files is the total number of files currently on the disk, including zero-length files. Comparing this figure to the Maximum Number of Files gives you an idea how many more files can be created on the disk. In such an estimation, it is important to note that files can vary greatly in size. Remember this is only an estimate.

Total Size of all Files is the number of disk blocks that are occupied. Blocks allocated to a file but not yet used are not counted. This is also presented as general disk information.

Smallest File Size is the size in blocks of the smallest file on the disk.

Largest File Size is the size in blocks of the largest file on the disk.

Mean Size of all Files is the average size of a file, calculated by dividing the total size of all files by the total number of files excluding zero-length files. In many cases, this figure can be used to determine the optimum disk cluster size.

 # Extent Headers is the number of extra (extension) file headers. This does not include the one (primary) header required for each file. Fragmentation at its worst comes in the form of a multi-header file. When a file header contains more retrieval pointers than can fit into a single one-block file header (usually approximately 70), OpenVMS allocates another header for the file. (Each retrieval pointer represents a single fragment of the file.) If the second header fills with retrieval pointers, (usually approximately 102 more), a third will be allocated—then a fourth, and so on. When a file is broken into enough fragments to fill the header with retrieval pointers, this is an indication of severe fragmentation.

Total File Fragments is the total number of pieces of files on the disk. Note that it is possible for this number to differ from, and even be less than, the *Total Number of Files* figure, because zero-length files are included in the *Total Number of Files*, but such files consist of zero fragments.

Mean Fragments per File shows how many fragments there are in the typical file on the disk (total number of fragments divided by total number of non-zero-length files). This is an index of how fragmented the files on the disk are. If the mean fragments per file is 1.00, the files are contiguous. If the figure is 1.10, then 10% of the files, on average, are in two pieces. 1.20 means 20%, 1.30 means 30%, etc. A figure of 2.00 means the files average two fragments each. 1.00 is the best figure attainable, indicating that all files or nearly all files are contiguous.

 # Reserved Files is the number of files reserved for use only by the file system. This figure is presented for general information, and is in some cases used by Executive Software in helping a Data Center Manager evaluate the fragmentation on a disk.

 # Placed Files indicates how many files on the disk are fixed at their current location using OpenVMS placement control. Placed files can disrupt large contiguous spaces, and can be an unnecessary burden on system resources. It is recommended that you not use OpenVMS placement control on a file unless it is absolutely necessary.

 # Multi-Hdr File Hdrs indicates the total number of headers associated with files that have more than one file header. This includes primary headers and extent headers. For an explanation of the meaning of multi-header files see the explanation of the *# Extent Headers* earlier in this section.

Multi-Volume Files indicates how many files on the disk span two or more disks in a volume set. This is presented as general file information. In some cases, dividing large files onto more than one disk can improve your I/O performance, since the I/O load is shared by the multiple disks.

Directory Files indicates how many directory files are on the disk. This, too, is presented as general disk information.

Zero Length Files indicates how many files have no blocks allocated to them. While they take up little space on the disk, these files waste space in INDEXF.SYS, and should be deleted if they are numerous.

Files with Frags >= 2 indicates how many files are fragmented (not contiguous). This is another important index of file fragmentation on the disk.

Lost Blks/Extent Cache is the result of the following calculation:

```
Number of Usable Blocks - (Total Free Space Size + Total Size of all Files)
```

Presented as general disk information, this value is derived from two arithmetic operations. The number of blocks known to be free is added to the number of blocks known to be in use. This sum is subtracted from the size of the disk to arrive at Lost Blks/Extent Cache. Therefore, this value represents all the blocks that are neither known to be free nor known to be in use. Their status is unknown. On an active disk, this is not alarming. These blocks may be any combination of:

— blocks marked allocated that are not actually part of a file;

— blocks held in the extent cache for the disk on another node of the cluster; or

— blocks that were added to the extent cache while the Fragmentation Analysis Utility was running.

Total Split I/Os indicates how many I/O operations since system boot time have been split into two or more I/O operations to retrieve data split across two or more fragments of a file. This is the most meaningful indicator of the actual cost of fragmentation on your system. This figure represents the number of split I/Os on a system-wide basis, *not* on a per-device basis.

2.4.9 File Sizes Summary

The table headed *File Sizes Summary* shows the number of files on the disk categorized by size in blocks. In Example 2–1, there are 335 one-to-two block files, 288 files from 3 to 6 blocks in size, etc.

2.4.10 File Fragments Summary

The table headed *File Fragments Summary* shows the number of files on the disk categorized by number of fragments. In Example 2–1, there are nine zero-length files, 1510 files with one fragment each (contiguous), six files with two fragments each, etc.

2.5 How to Print the Fragmentation Analysis Utility Output

To obtain a printout of the Fragmentation Analysis Utility output, set the output qualifier to any user-selected file name. At the DCL prompt, type:

```
$ FRAG_MENU ANALYSIS disk_name /OUTPUT=filespec
```

Then when the analysis has completed:

```
$ PRINT filespec
```

Note: The figures provided by the Fragmentation Analysis Utility constitute a rolling snapshot of the state of the disk, so the figures can be inconsistent at times.

2.6 When Free Space Reported by Fragmentation Analysis Utility Does Not Agree with SHOW DEVICES

The Fragmentation Analysis Utility reports the degree of fragmentation of the files and free space on a disk. It reports two items, *Total Free Space Size* and *Lost Blks/Extent Cache* that, when added together, reflect the total amount of free space on the disk. Sometimes on an active disk, the Free Blocks value reported by SHOW DEVICE does not agree with this figure due to extent cache and blocks that OpenVMS has marked free but has not yet marked allocatable. A discrepancy is especially likely on a VAXcluster™, since each node has a separate extent cache for each disk.

To clear the extent cache and get a correct report of Free Blocks from SHOW DEVICE, request the allocation of a ridiculously large amount of space. For example:

```
$ COPY/ALLOCATION=1000000000  NL:  filename.ext
```

No copy or allocation is actually completed, but SHOW DEVICE will then report a number of Free Blocks that corresponds with the Fragmentation Analysis Utility report.

3 FRAGMENTATION COST ANALYSIS OPERATION

The Fragmentation Cost Analysis gathers information about your system and its users, then estimates the cost of fragmentation on your system. It also provides a written analysis showing the estimate of how much fragmentation is costing you.

3.1 Before Running the Fragmentation Cost Analysis

In order to calculate the estimated cost of fragmentation on your system, it is necessary for you to gather information about your system. Specifically, the following factors are good indicators of the effects of fragmentation, and are used by the Fragmentation Cost Analysis in determining the cost of fragmentation on your system:

- Approximate percentage of free disk space
- Amount of CPU idle time
- Average split transfer rate, or number of split I/Os (occasions when the system must read from the disk more than once to satisfy an I/O request)

3.1.1 Determining the Approximate Free Disk Space on your System

The amount of free disk space on your system can impact the effect of fragmentation on your system. Systems with little free space are slowed by fragmentation to a greater degree than those with ample free space.

One of the questions asked by the Fragmentation Cost Analysis is in regards to the approximate percentage of free disk space on your systems. Many Data Center Managers already have a good idea of this percentage, but if you do not, perform the following steps on the most heavily-used disks on your system to get an approximate figure:

1 Issue this command at the DCL ($) prompt, where *device_name* is the name of a heavily-used disk device on your system:

```
$ SHOW DEVICES /FULL device_name
```

This will cause a display similar to the one shown in Figure 3–1:

Figure 3–1 Sample SHOW DEVICES Output

```
Disk BOOT$DKA200:, device type RZ23, is online, mounted, file-oriented device,
    shareable, available to cluster, error logging is enabled.
    Error count                    0    Operations completed            126176
    Owner process                  ""   Owner UIC                      [SYSTEM]
    Owner process ID        00000000    Dev Prot    S:RWED,O:RWED,G:RWED,W:RWED
    Reference count                1    Default buffer size                512
    Total blocks              204864    Sectors per track                   33
    Total cylinders              776    Tracks per cylinder                  8
    Host name                 "BOOT"    Host type, avail   VAXstation 3100, yes

    Volume label           "USERDISK"    Relative volume number              0
    Cluster size                   3    Transaction count                   1
    Free blocks                25269    Maximum files allowed           25608
    Extend quantity                5    Mount count                         6
    Mount status              System    Cache name        "_$4$DKA700:XQPCACHE"
    Extent cache size             64    Maximum blocks in extent cache   2526
    File ID cache size            64    Blocks currently in extent cache    0
    Quota cache size               0    Maximum buffers in FCP cache      305

  Volume status:  subject to mount verification, file high-water marking, write-
      through caching enabled.

$
```

2 Divide number of free blocks by the total number of blocks, and multiply the result by 100. In the example shown above, the calculation would be:

```
(25269 / 204864) * 100 = 12.33%
```

Since the Fragmentation Cost Analysis prompts you to estimate how *full* your disks are, subtract the percentage calculated in the formula above from 100 (i.e. 100 - 12.33 = 87.67% full).

Note that this calculation does not take into account blocks of space in the extent cache, but the figure it produces will suffice for the purpose of the Fragmentation Cost Analysis.

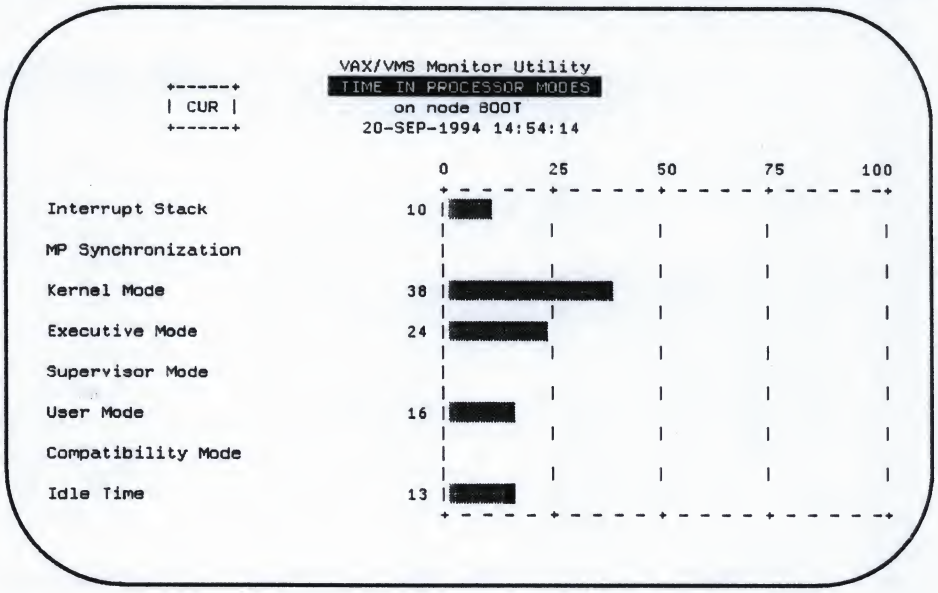
3.1.2 Determining the CPU Idle Time on your System

The amount of CPU idle time available on your system can be affected by the fragmentation of files on your disks. A heavily fragmented system consumes Kernel Mode time due to the increased number of disk I/Os. This, in turn, reduces the amount of available CPU idle time. To determine the amount of CPU idle time available on your system, enter this command at the DCL ($) prompt at a time when your system is being heavily used:

```
$ MONITOR MODES
```

This will cause a graph similar to the one shown in Figure 3–2 to be displayed:

Figure 3–2 Sample MONITOR MODES Output



Observe the bottom line of the graph during a peak period of the day and note the range in which it fluctuates. This information will be used when you run the Fragmentation Cost Analysis.

3.1.3 Determining the Split Transfer Rate on your System

The split transfer rate (or split I/O count) indicates the number of I/O operations that have been split into two or more I/O operations to retrieve data that is in two or more fragments of a file. This is the most meaningful indicator of the actual cost of fragmentation on your system.

To determine the split transfer rate on your system, enter this command at the DCL ($) prompt at a time when your system is being heavily used:

```
$ MONITOR IO
```

This will cause a table similar to the one shown in Figure 3–3 to be displayed:

Figure 3–3 Sample MONITOR IO Output

VAX/VMS Monitor Utility
I/O SYSTEM STATISTICS
on node BOOT
20-SEP-1994 14:56:32

	CUR	AVE	MIN	MAX
Direct I/O Rate	1028.90	567.71	14.52	1070.29
Buffered I/O Rate	5.31	15.54	2.31	35.43
Mailbox Write Rate	0.00	0.03	0.00	0.65
Split Transfer Rate	1.03	1.21	0.00	2.73
Log Name Translation Rate	3.98	3.92	0.00	32.78
File Open Rate	0.66	2.48	0.00	6.31
Page Fault Rate	29.56	25.01	0.00	180.39
Page Read Rate	2.32	1.78	0.00	15.61
Page Read I/O Rate	1.32	0.44	0.00	3.98
Page Write Rate	0.00	0.00	0.00	0.00
Page Write I/O Rate	0.00	0.00	0.00	0.00
Inswap Rate	0.00	0.00	0.00	0.00
Free List Size	13238.00	13328.59	11119.00	13655.00
Modified List Size	1543.00	1512.90	1445.00	1855.00

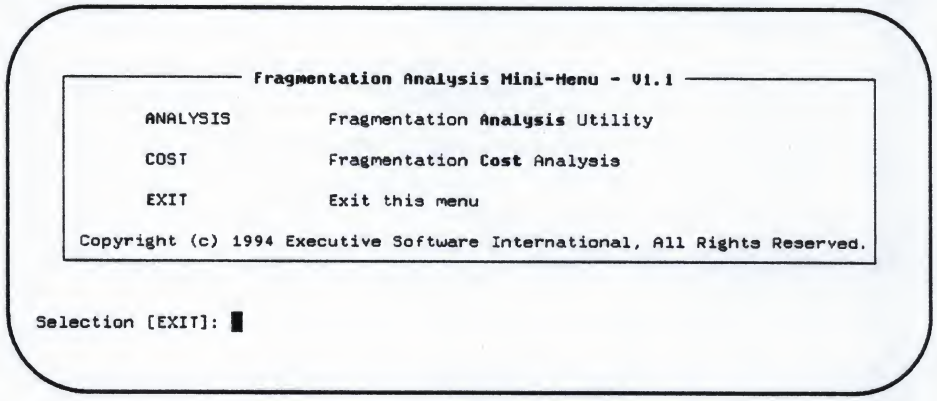
The figures in the table reflect data gathered starting at the time you issue the MONITOR command. For this reason, you should allow the display to run for a period of time, at least several minutes. This ensures the information gathered is representative of your system's workload.

The fourth line shows the split transfer rate. Note the figure ahown in the "AVE" (for average) column after the display has run during a peak period of the day. This information will be used when you run the Fragmentation Cost Analysis.

3.2 Running the Fragmentation Cost Analysis

After the **FRAG_MENU** symbol has been defined as described in Section 1.10, enter **FRAG_MENU** at the DCL prompt to invoke the Fragmentation Analysis Mini-Menu. This causes the menu shown in Figure 3–4 to be displayed.

Figure 3–4 Fragmentation Analysis Mini-Menu



Invoke the Fragmentation Cost Analysis by entering **COST** (or simply **C**) at the **Selection [EXIT]:** prompt.

This starts a series of screens and prompts where you will answer the following sequence of questions:

- Your company name
- Your first and last name
- How full your disks are
- How much CPU idle time your system has
- The average Split Transfer rate (split I/Os) on your system
- What your computer is primarily used for (one or more of these choices):
  - » Backup or redundant system
  - » Research and Development
  - » Running inventory control or production control applications
  - » Running word processing, text editing, or electronic mail
  - » Running databases that use pre-allocated disk space
  - » Running CAD/CAM applications
  - » Compiling or executing FORTRAN/Ada/BASIC or other languages
  - » Running databases that do NOT use pre-allocated disk space
- How many hours per day your computer is being used with users logged in
- Whether your system is part of a computer cluster
- The approximate cost of your computer system
- What is the expected payback period for of your computer system in months

- The number of 8-hour shifts worked at your site
- Your monthly cost of hardware maintenance and software update service
- The number and average salaries of the following computer operations personnel:
  - » Computer Operators
  - » System Managers
  - » Programmers
  - » Database Administrators
  - » MIS Directors
- The number and average salaries of the following full and part time computer users:
  - » Clerical personnel
  - » Sales personnel
  - » Management personnel
  - » Research/Scientific personnel

After the data has been gathered, the Fragmentation Cost Analysis creates a text file named FCA_REPORT.RPT located in the directory from where the Fragmentation Cost Analysis was invoked.

As an option, the Fragmentation Cost Analysis can also send you (via the OpenVMS MAIL utility) a copy of the FCA_REPORT.RPT file.

The FCA_REPORT.RPT file is a comprehensive report showing the information you have input, as well as the calculations used to determine the estimated cost of fragmentation on your system. This report also shows:

- Estimated monthly system costs lost due to fragmentation
- Estimated monthly computer personnel salary costs wasted due to fragmentation
- Estimated monthly user salary lost due to fragmentation
- Total estimated monthly fragmentation-related costs and losses

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